REMARKS

Paragraph 1 of the Office Action

The Examiner has rejected claim 16 because the word "tin" was omitted at the end of the second line of the claim. Claim 16 has been amended to correct this typographical error.

Paragraphs 2 and 3 of the Office Action

In paragraphs 2 and 3 of the Office Action, the Examiner rejects claims 1-5 and 9-17 under 35 U.S.C. § 103(a) as unpatentable over Tache (U.S. Patent No. 3,299,482) in view of Bostater et al. (U.S. Patent No. 4,493,359). In his rejection, the Examiner states,

> "Tache et al. disclose a gray iron casting process and composition for making engine component parts by adding a tin alloying element, in which the composition includes (by weight percent): 3.05 to 3.45% carbon (carbon equivalent between 3.786 and 4.15%), 1.7 to 2.1% silicon, maximum 0.15% phosphorus, maximum 0.12% sulfur, 0.05 to 0.9% manganese, maximum 0.15% chromium, 0.05 to 0.08% tin and balance iron (column 1, lines 11-16; column 3, lines 1-56 and 70-76; and column 4, lines 1-46). Preferably, the tin is added to the molten gray iron in the cupola during filling of the pouring ladles by addition of preweighed chunks of metallic tin in the range of 0.05% to 0.08% by weight, resulting in a molten alloy of tin with gray iron, followed by subsequent (as soon as possible) casting into mold(s) to produce the engine components (column 3, line 75; and column 4, lines 1-46). After the molten gray iron composition is poured into molds while the molten metal is at about 2550 to 2650 degrees F, the resulting casting is cooled and taken to core knock-out and shake-out stations while the bores are still at temperatures of about 1450-1500 degrees F (column 1, lines 55-70). Although Tache et al. disclose a composition that includes silicon within the gray iron alloy, Tache et al. do not disclose the step of adding further silicon as an inoculant to the molten gray iron alloy.
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> However, Bostater et al. disclose a method for making cast iron engine blocks from a casting process with molten gray iron, in which a silicon-containing inoculant (foundry grade ferrosilicon containing 23% iron and 7.5% silicon, ranging from 100 to 300 ounces of inoculant per 1,600 pounds of molten metal) is added to a molten gray iron composition (that already contains silicon) and stirred within a casting ladle for subsequent pouring into casting molds (abstract; column 1, lines 6-13; column 3, lines 3-21 and 52-68; column 4, lines 1-3 and 50-60; column 5, lines 54-68; column 6, lines 1-15; column 7, lines 4-26; and Figure). A sample of molten metal in the holding furnace was taken periodically for thermal analysis to obtain control of the carbon equivalent value (at a desired level of about 4%) within the molten gray iron (column 5, lines 42-53 and Figure). Castings of various cross-sections, including those that have very thin walls which would otherwise have high casting scrap losses, are able to be produced due to the molten metal homogeneity and addition of silicon-containing inoculant, with the advantageous feature of achieving a low casting scrap rate of less than 5% (column 2, lines 21-24; column 3, lines 3-21 and 33-40; column 4, lines 44-65; column 5, lines 54-68; column 6, lines 1-15; and column 7, lines 23-39). The additional step of adding a silicon-containing inoculant is advantageous for producing gray iron castings of various cross-sections with a substantial increase in

> the uniformity of molten metal as poured (column 4, lines 44-49; column 5, lines 57-68; column 6, lines 1-15; and column 7, lines 23-40).
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> It would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to modify the gray iron casting process and composition for making engine component parts by adding a tin alloying element, as disclosed by Tache et al. by using the additional step of adding and stirring a silicon-containing inoculant to the molten gray iron composition that already includes silicon, as taught by Bostater et al., in order to produce gray iron castings of various cross-sections with a substantial increase in the uniformity of molten metal as poured (Bostater et al.; column 4, lines 44-49; column 5, lines 57-68; column 6, lines 1-15; and column 7, lines 23-40)."

Applicants respectfully traverse the Examiner's rejection of claims 1-5 and 9-17 as amended. Applicants submit that their method uses a unique and unobvious combination of steps, alloying elements and concentrations to achieve results that are neither sought after or disclosed by the cited references.

Mr. Joseph R. Ward, the inventor, has a Bachelor of Science degree in Metallurgical Engineering and over thirty years of experience as a metallurgist working in casting operations. Mr. Ward has studied the Tache et al. and Bostater et al. patents and has submitted a Declaration in this application.

As set forth in paragraph 3 of Mr. Ward's Declaration, " The invention of this patent application is a method of casting with a grey iron that is not taught by the Tache and Bostater et al. patents. In our method, very low levels of carbide stabilizers, such as chromium and phosphorus, and a low level of tin are used in a molten grey iron casting metal, which is inoculated with silicon to a level of about 0.10% to about 0.12% while it is in the pouring ladle, and poured as soon as possible after inoculation, and the castings are shaken out while they are hot, in excess of 1400°F. Our invention provides castings with high strength and minimal iron carbide hard spots and chills, low residual stresses in reduced casting times and without additional equipment."

The Examiner erroneously treats Tache's disclosure as equivalent to Applicants' claimed invention, except for the step of adding further silicon as an inoculant to the molten gray alloy. In the rejection, the Examiner recites the composition that is disclosed in the Tache reference at column 3, lines 40-50. Applicants' claimed method provides a different alloy than that taught by Tache. While the carbon equivalents of Tache's disclosed composition and Applicants' gray iron metal alloys are substantially alike, Tache teaches alloying agents different than those used in Applicants' claimed method. Tache's alloy includes manganese in an amount of 0.5 to 0.9%; Applicants' teaching is to use manganese at about 1.7 times the percentage of sulfur, plus about 0.3 to about 0.4%. Tache teaches that

phosphorus can be used up to 0.15% while Applicants' alloy contains less than about 0.03% phosphorus. Tache teaches that sulfur can be up to 0.12%, while in Applicants' alloy, sulfur is maintained at about 0.05 to about 0.07%, and Tache's alloy may have chromium of up to 0.15%, while in Applicants' alloy the chromium is less than 0.10%. Thus, the alloy used in Applicants' method is different than that taught by Tache.

While Tache discloses alloying his gray iron alloy (which is different than Applicants' alloy) with tin, in the preferable amount of 0.05% to 0.08%, Tache does not disclose the steps of inoculating the molten tin-alloyed controlled content gray iron metal with a gray iron inoculant to a further silicon addition of from about 0.10% to about 0.12% of silicon, or pouring the molten tin-alloyed, inoculated controlled content gray iron metal as soon as possible after the inoculation into a casting mold, or shaking out the resulting casting while they are over 1400°F.

As set forth in paragraph 4 of the Ward Declaration, "The Tache patent does not teach our method. The Tache patent does not teach the use of low levels of carbide stabilizers, reduced casting times and hot casting shake out. To the contrary, Tache's castings remain in the molds such long times that Tache adds tin to stabilize the hardness of the casting, and Tache does not teach inoculation of a molten grey iron to a further silicon content of about 0.10% to about 0.12% silicon and pouring as soon as possible after inoculation, and shaking out the castings while they are over 1400°F. In addition, Tache uses high levels of chromium and phosphorus, both of which promote hard spots in castings."

The Examiner cites Tache's disclosure at column 3, line 75 through column 4, line 46, incorrectly as indicating that Tache discloses pouring his molten metal into molds as soon as possible. Tache contains no disclosure indicating that time is a factor that should be reduced following the inoculation of the molten tin-alloyed controlled content grey iron metal because Tache, among other reasons, does not teach the inoculation of molten tin-alloyed controlled content grey iron metal to a further silicon addition from about 0.10 to 0.12%. Tache's only disclosure regarding the time involved in pouring is at column 1, lines 54-57, "The ladles are then transferred to the pouring line and the molds are filled at the prescribed temperature (2550°F to 2650°F) at a proper rate." The Tache disclosure does not teach or suggest that a molten tin-alloyed, inoculated controlled content gray iron metal should be poured as soon as possible after inoculation.

Furthermore, the problem that motivated Tache in his invention was different than the motivation for Applicants' invention. Tache states, for example, in describing the results of a casting with the composition set forth at column 2, lines 16-25, which does not contain any

alloying tin, "...repeated field complaints of a high incidence of bore wear and oil consumption on engines revealed on investigation that the bores were quite soft, as low as 110 Brinell and had a microstructure unsuitable for the type of service to which the castings were to be subjected." (column 2, lines 26-32). Tache further states, "Further investigation showed that most of the soft blocks were either the result of normal shutdown of the foundry molding and cooling line conveyors described above such as for lunch hour, shift changes, or overnight stoppage, or due to unforeseeable line stoppages because of equipment failures. In each of these instances the castings were retained for extended periods in the molds or on the cooling conveyors prior to core knock-out. Such permitted the bores to self-anneal because of the slow cooling rate through the secondary graphitizing range of approximately 1450°F to 1200°F." (column 2, lines 38-48).

Tache's solution to this problem was "...to treat and modify the gray iron composition to stabilize the microstructure during the periods of slow cooling to minimize the production of soft bores and poor wearing surfaces on the castings. In this connection, it had been found that these soft castings were evidenced by the formation of substantial amounts of free ferrite and that control of this action, if possible, could be beneficial." (column 2, lines 61-68). Tache further states, "...it was found that if tin, in certain critical quantities in the range of 0.04 to 0.10 was used in gray iron compositions of the above general character, that it was possible to obtain satisfactory castings substantially free of soft bores and having high wear resistant surfaces by the normal production methods that had previously caused the above described difficulties when normal or abnormal stoppages occurred in the casting line." (column 3, lines 18-26).

On the other hand, Applicants' invention sought an economical method for manufacturing gray iron crank cases and cylinder heads having minimal iron carbide hard spots and chills upon solidification, minimal need for stress relief treatment of the finished casting and shortened cooling times, through hot shake-out temperatures. See Applicants' specification, page 2, lines 5-9. As a result of Applicants' invention, this method of manufacture uses a molten gray iron metal that has, compared with prior manufacturing methods, substantially increased carbon levels, lower levels of phosphorus, significantly lower levels of chromium, somewhat lower levels of sulfur, which, with the alloying use of tin as a pearlite stabilizer, substantially reduces the potential for carbide hard spots and chills and allows significantly reduced silicon content in the gray iron and minimal inoculation additions while achieving higher shake-out temperatures and providing castings with lower

residual stresses. See Applicants' specification, page 2, lines 23-29, and paragraphs 3 and 4 of Mr. Ward's declaration.

As indicated above, Tache discloses the use of phosphorus up to 0.15%, five times the level of phosphorus used in Applicants' method; Tache discloses the use of chromium up to 0.15%, one and one-half times the level of chromium used in Applicants' method, and Tache does not disclose an inoculation of his alloy to a level of 0.10% to about 0.12% silicon, pouring the inoculated molten metal as soon as possible after inoculation or shaking out castings at temperatures in excess of 1400°F.

Applicants' invention is not disclosed, taught or suggested by Tache.

Furthermore, the combination of Tache and Bostater et al., U.S. Patent No. 4,493,359, fails to disclose, teach or suggest Applicants' invention. Tache and Bostater et al. have disparate disclosures and would not be combined by one of ordinary skill in the art as the Examiner has combined them. The Examiner's combination of Tache and Bostater et al. can only be the result of his hindsight view of the references, resulting from Applicants' invention.

As set forth by Mr. Ward in paragraph 6 of his declaration, "I do not believe the combined teachings of the Tache patent and Bostater et al. patent teach our casting method. The combined teachings of the Tache and Bostater et al. patents do not teach a casting method in which a molten grey iron with very low levels of carbide stabilizers and a low level of tin is inoculated with silicon to a level of about 0.10% to about 0.12%, is poured as soon as possible after inoculation, and in which the resulting castings are removed from the molds at over 1400°F. Furthermore, I do not believe a skilled metallurgist, trying to develop castings with high strength, minimal iron carbide hard spots and chills, low residual stresses in reduced casting times and without additional equipment, would combine the teachings of the Tache patent and the Bostater et al. patent, whose teachings are directed to different problems."

As further set forth in Mr. Ward's Declaration at paragraph 5, "The Bostater et al. patent is also not significant to our invention. It appears that the Examiner has referred to the Bostater et al. patent only because it discloses inoculation of a grey iron metal with a ferrosilicon inoculant. Inoculation with silicon containing inoculants has been done for years and is a common foundry practice. However, in the method of our invention, molten grey iron casting metal with very low levels of carbide stabilizers and tin, is inoculated to provide a further silicon addition of 0.10% to 0.12% by weight, is poured into the molds as soon as possible after inoculation, and the resulting castings are shaken out of the mold while they are

over 1400°F. The Bostater et al. patent does not teach these steps. The Bostater et al. patent is concerned with obtaining fluidity of the molten casting metal by maintaining it in a holding furnace for at least one and one half hours so the molten metal will satisfactorily form thin walls in an engine block casting. Unlike our invention, which requires no new equipment, the Bostater et al. patent also indicates that its disclosed process requires a holding furnace of massively increased capacity."

The problem with which Bostater et al. were concerned is described, for example, as follows,

> "By far most of the defects occur in the thinnest wall portions of the castings, and the thinner the walls, the greater the scrap loss. At present, a scrap loss of about five percent in the casting operation is accepted by the industry as being nominal for engine blocks wherein the minimum wall thickness is about 0.180 inches. For engine blocks having substantially smaller wall thicknesses, for example, 0.150 inches, there is a dramatic increase in scrap loss, typically to as high as twenty-five percent. Such scrap losses are prohibitive as regards the manufacture of engine blocks for high production automobiles and trucks, and hence it is currently the practice of the automotive industry to design all high-production engines to have engine block wall thicknesses of at least 0.180 inches. It is this limitation on the design of engine blocks that has become an ever-increasing problem in the attainment of lesser gross vehicle weight.
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> The present invention solves this problem by providing a method whereby cast iron engine blocks can be made with wall thicknesses substantially less than are now used, without any increase in scrap loss...A cardinal feature of the method of the present invention is that after the molten grey metal is made it is held at a substantially constant temperature for a period of from one and one-half to two and one-half hours prior to being poured into the molds." (column 2, lines 23-53).

Bostater et al. also state, "Because the temperature in the molten metal in the holding furnace is maintained substantially constant, during the lengthy residence time of the molten metal in the holding furnace there is attained not only an increase in homogeneity of the metal composition but also an increase in the uniformity of the temperature of the molten metal throughout its mass. The increased uniformity in composition and the increased uniformity in temperature are important not only in and of themselves but also important in better assuring a constancy in the fluidity of the molten metal. With this increased uniformity in composition, temperature and fluidity, the flow and the cooling of the molten metal poured into the mold are of an improved, controlled uniformity." (column 3, lines 3-18).

Bostater et al. further state that in their invention, "The metal formulation can be any of those well known in the art for machinable grey cast iron, preferably having a chemistry as poured, which includes, by weight, from 3.30% to 3.60% C, from 2.10% to 2.65% Si, from

0.05% to 0.09% P, from 0.5% to 0.7% Mn, from 0.15% to 0.25% Cr, from 0.1% to 0.15% Ni, and from 0.15% to 0.25% Cu, 0.15% maximum S and the remainder Fe." (column 3, lines 51-59). This metal formulation is different from both Tache's metal alloy and the alloy used in Applicants' invention.

Thus, Bostater et al. disclose an alloy having substantially higher values of silicon, phosphorus and chromium than those used in Applicants' method, and unlike Applicants' method, Bostater et al. disclose the use of quantities of nickel and copper, and the use of manganese in an amount equal to 0.61%. Bostater et al. do disclose the inoculation of their alloy with a ferrosilicon inoculant; however, Bostater et al. do not disclose Applicants' steps of inoculating Applicants' molten tin-alloyed, controlled content gray iron metal with an inoculant to further the silicon addition of from about 0.10% to about 0.12%, and removing the castings from the molds while they are over 1400°F.

Bostater et al. are interested only in obtaining molten metal with sufficient fluidity to reliably form walls having a thickness of about 0.150 inches. Unlike Applicants' invention, Bostater et al. do not disclose a concern with minimizing iron carbide hot spots and chills upon solidification, minimizing the need for stress relief heat treatment of the finished castings, or minimizing cooling times, by obtaining hot shake-out temperatures. Unlike Applicants' method of manufacture, Bostater et al. do not disclose or teach lower levels of phosphorus, significantly lower levels of chromium, somewhat lower levels of sulfur and the alloying use of tin as a pearlite stabilizer to substantially reduce the potential for iron carbide hot spots and chills, and do not teach a significantly reduced silicon content and minimal inoculate additions. Contrary to Applicants' invention, Bostater et al. teach the use of expensive alloying agents copper and nickel that are no part of Applicants' invention.

Furthermore, Applicants' invention requires no additional processing equipment, however, as stated by Bostater et al., "Further, in accordance with the preferred embodiment, this is accomplished by the use of a holding furnace of massively increased capacity, as compared to the holding furnaces heretofore used." (column 2, lines 52-56). (Emphasis Added).

Mr. Ward states in paragraph 3 of his Declaration:

> "In our method, very low levels of carbide stabilizers, such as chromium and phosphorus, and a very low level of tin, are used in molten grey iron casting metal, which is inoculated with silicon to a level of about 0.10% to about 0.12% while it is in the pouring ladle, and poured as soon as possible after inoculation, and the castings are shaken out while hot, in excess of 1400°F."

Even if Tache et al. and Bostater et al. were combinable, which is contrary to Mr. Ward's Declaration, their combined teachings would provide an alloy with about twice the percentage of the carbide stabilizer phosphorus, about one hundred fifty percent of the carbide stabilizer chromium that are used in Applicants' method, and would further include 0.15% to 0.25% nickel and 0.15% to 0.25% copper. Such teachings are contrary to the invention and Applicant's use of "very low levels of carbide stabilizers."

Thus, one of ordinary skill in the art would not combine the teachings of Bostater et al. with those of Tache, and in any event, their combination would not achieve the results sought by Applicants in their invention of minimal iron carbide hotspots and chills, minimal need for stress relief, a requirement of no additional processing equipment and reduction of production time achieved by shake-out at temperatures over 1400°F.

Applicant has amended claims 1 and 15 to change "consisting of" in claim 1 and "consists essentially of" in claim 15 to "comprising" and "comprises," respectively. Accordingly, the Examiner's comments at the end of paragraph 3 and in paragraph 5 no longer apply to Applicants' claims.

Applicants respectfully submit that Tache and Bostater et al. do not disclose, teach or suggest the claimed invention and Applicants respectfully submit that the claims of this application are in condition for allowance.

Respectfully submitted,

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